WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: The PEARL CD: Public Educational Access to Resources on Lakes *(A GIS-based internet database for Maine lakes.)*

Focus categories: EDU, SW, WQL

Keywords: Education, Geographic Information System, Lakes, Ponds, Water Quality Monitoring.

Duration: 3/1/00-2/28/01

Federal Funds Requested: $12,765.

Non-Federal Funds Pledged: $28,567.

Principal Investigators: M. Kate Beard (National Center For Geographic Information and Analysis), John Peckenham (Water Research Institute), and J. Steve. Kahl (Water Research Institute).

Congressional District: Second

Statement of Critical Regional Problem

Recreationally, aesthetically, and economically, Maine's 6,000 lakes are important features contributing billions of dollars to the state economy (Boyle *et al.*, 1997). However, one of the key information issues that has hampered the efforts of researchers, water quality monitors, regulators, planners, educators, and stewards is access to information about Maine lakes. To resolve this problem, and to promote stewardship and awareness about lakes, the Water Research Institute at the University of Maine has developed PEARL (*Public Educational Access to Resources on Lakes*). Until the advent of PEARL, locating and using information available on Maine lakes was complicated by the number of agencies who independently collect and store these data. Prior to developing a uniform GIS database, the range of electronic (and hardcopy!) data formats were generally incompatible.

Statement of Results and Benefits

PEARL will be the only uniform resource for historical and geographical information, as well as fisheries and water quality data related to Maine lakes. PEARL is accessible on the Internet using World Wide Web network protocols from any Web browser (*http://pearl.spatial.maine.edu*), and is linked with all libraries and most schools in Maine through the University of Maine URSUS system (*University Resources Serving Users Statewide*). PEARL is fully GIS-based. Since inception in 1997, PEARL has averaged over 10 hits per day.

PEARL has four basic functions: 1) data search, 2) data display, 3) information reporting, and 4) data input. PEARL supports two search strategies: *location-based* and *feature-based*. The location-based search uses a zoomable map display that allows a user to highlight lakes as depicted on a map. The *feature-based* mode assumes the user knows the name of a feature (lake) but not necessarily its location. Once a lake is identified, the user is given the option to view physical and chemical information about the lake. The lakes database is complete for names, locations, sizes, and MIDAS reference (unique lake reference number) and water quality monitoring data have been entered. To date a sizable quantity of raw data and metadata still needs to be converted to a suitable format, reviewed, and made part of PEARL. The requested support for PEARL will be directed towards database preparation. The new *report* functions will allow users to select which attributes (lake data) they wish to compile from a search-results table. This function is a separate feature from the search functions. They will be able to select from the set of physical, biological, chemical and monitoring attributes available in the database. The report format will change depending on whether the report is for an individual feature or for a set of features. For the report function, users will have the ability to sort the result set using selectable logical filters.

The data contained in PEARL can be made available to even more users through a CD-ROM version. This format will also be useful for people who want to use the data in remote locations. The CD-ROM will contain the same data as the web version and will allow the user to perform attribute manipulation and GIS-type interpretations.

A *steering committee* has been established to oversee the implementation of PEARL, and to ensure that this effort merges seamlessly with future natural resource data activities. This statewide group of ten representatives includes the Volunteer Lake Monitoring Program, U.S. Geological Survey, and Maine Department of Environmental Protection. Members at the University of Maine include: the National Center for Geographic Information and Analysis, Project WET, and the Water Research Institute. *PEARL is an essential part of a continuing relationship between the Water Research Institute and statewide partners of the Advisory Committee.*

Table 1. The PEARL Steering Committee.

Organizations:

  S. Williams, Executive Director, Volunteer Monitoring Program

Federal Agency:

  R. Lent, Bureau Chief, US Geological Survey, Water Resources Division, Augusta

Maine State Agencies:

  R. Bouchard, Lakes Coordinator, Dept. Environmental Protection

  J. Potvin, Lakes Program, Dept. Environmental Protection

  L. Bacon, Lakes Program, Dept. Environmental Protection

University of Maine:

  M.K. Beard, National Center for Geographic Information & Analysis

  M.A. McGarry, Maine Coordinator, Project WET, Maine Dept. of Conservation

  S. Kahl, Director, Water Research Institute

  J. Peckenham, Senior Research Scientist, Water Research Institute

Nature, Scope and Objectives of the Research:

The WRI advertises and promotes PEARL through its newsletter, web site professional contacts, and annual Water Conference. PEARL provides a mechanism for developing a new format for the information collected by the Volunteer Monitoring Program, tapping into a network of 350 volunteers on 400 lakes. In addition, Project WET (Water Education for Teachers) has been featuring PEARL in its programs and presentations since 1998. This is producing a broad constituency of students, teachers, and citizen users with knowledge of PEARL.

PEARL now supports the first two of these four basic functions:

1) data search; 2) data display; 3) information reporting (to be developed), and 4) data input (to be developed).

The first three functions are closely integrated. The ***search*** function is key to the success of PEARL in allowing users to search for information on lakes in an intuitive way. PEARL now supports two basic search strategies, which are linked: one location-based and the other feature-based. The location-based search assumes a user has a location in mind but may not know any feature names. This search strategy is supported by a map ***display*** and a small set of map tools that allows users to zoom in and out and to select features (lakes) from the map by clicking on them. The outcome of this search request is that a selected feature is identified on the map and a listing of selected attributes of the feature is displayed. The feature-based mode assumes the user knows the name of a feature (lake) they wish to search for but not necessarily the location. They can enter a feature name by typing its name or selecting from a list (pull-down menu). The outcome is the same as the map-based search: the selected feature is highlighted on the map and selected attributes of that feature are displayed. A proposed extension of the feature-based query will allow users to select a set of features (data categories) that satisfy a set of logical constraints. The display of this result set requires additional processing so those users can compare and contrast elements of the set. In other words we have two ***reporting*** and ***display*** strategies: one for reports on individual features and one for comparative reporting among lakes. Within the display mode, additional options will include graphic data display or table format. Either would be available for downloading, with the table format especially useful for researchers and state agency staff.

The proposed enhanced search function will be integrally linked with a set of display and reporting tools so that users can see, compare, analyze and print out their search results. The set of display functions will include an ability to modify the base map display (add or subtract layers), to change symbolization, to change which attributes are displayed, and to provide hardcopy output of the map display.

The ***report*** functions will allow users to select which attributes they wish to report. They will be able to select from the set of physical, biological, chemical and monitoring attributes available in the database. The report format will change depending on whether the report is for an individual feature or for a set of features. For the reporting of sets of features, users will have an ability to sort the result set on selected attributes. For example they may wish to initially sort the information elements in a PEARL data summary table by lake size and to later sort by pH. This will provide users with a quick interactive way to view and compare lakes with certain characteristics.

The development of PEARL includes a substantial amount of effort to get the basic GIS template operational with the key chemical, physical, biological, and political information. This task will be continued under funding provided by this proposal. New GIS data will be added to PEARL as it becomes available. PEARL will also have a ***data entry*** function for new lake data generated in Maine, with one focus being the annual data collection in the Volunteer Monitoring Program. The data input function will be especially valuable in supporting information gathering from volunteer organizations.

This will take the form of input screens that will allow contributors to type in information on lake attributes from remote locations. This information will be loaded to a separate database where it can be verified before being officially incorporated into the publicly available database of PEARL. The proposed CD-ROM version will perform with the same capabilities as the web version.

A key advantage for VMP is that the data will be available in a nearly 'real time mode', rather than once per year on a much delayed time frame. The relationship with VMP and DEP will provide much of the long term rationale and commitment for PEARL, in conjunction with the strong commitment from the Water Research Institute.

Our objectives are:

> *1) To compile the information available for Maine lakes into an on-line user-friendly Web site on the Internet and to develop a companion CD-ROM version.*
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> PEARL includes physical, chemical, and monitoring information, and fisheries status where available. A fraction of the historical information has been converted and a mechanism needs to be developed to allow new data to be entered from the source agencies. Relevant publications of the University of Maine, state agencies, Congress of Lakes Association (COLA), and the VMP will be included. The system is built around a dynamic GIS-based database maintained and continually updated by the University of Maine Water Research Institute in collaboration with the Maine DEP and the Volunteer Monitoring Program.
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> *2) To enhance communication among agencies and organizations, and to provide information services with a vision toward the future.*
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> A steering committee has been established to oversee the process and progress for PEARL, and to ensure that this effort merges seamlessly with ongoing and future natural resource data activities in Maine. The 10 members of the Steering Committee are listed in Table 1. With the guidance of the Steering Committee, PEARL is integrated with the Maine GIS hydrologic network maps complied by the Office of Geographic Information Systems and the Nation Center for Geographic Information and Analysis.
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> *3) To improve public knowledge about lakes and water quality, Project WET incorporates PEARL into its workshop activities and curriculum materials.*
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> The University of Maine WRI administers the Maine chapter of National Project WET. Maine Project WET offers workshops around the state to engage educators with the extensively field-tested activities and curricula

materials of WET. Maine Project WET also acts as a repository for disseminating information about successful water resource educational efforts in the state. The coordinator of Project WET in Maine seeks to customize the activities with information, examples, and data relevant to the state's citizens. PEARL facilitates this mission by using a demonstration CD-ROM with more GIS-capabilities, the CD-ROM will be developed into a fully functional version of the database.

4) To develop the next generation of annual lake reports for the Volunteer Monitoring Program.

Before the advent of PEARL, 350 volunteer monitors, 260 lake associations, DEP staff, and researchers statewide compiled data for lakes into an unwieldy set of three ring binders that was printed each year at considerable expense by DEP. As part of PEARL, a collaboration of VMP, DEP, and the University of Maine will produce a new format for these data, much of which will be in PEARL for instant updating.

5) To support the legislature's goal of establishing a new classification system for Maine lakes.

The 1995-97 Great Pond Task Force (GPTF) and its successor board have been charged with creating a new classification system for Maine lakes. Implementing such a system requires access to accurate and complete information before the advent of PEARL was tedious to obtain. The GPTF was unable to complete the task of a new classification system in large part because of poor access to information. PEARL, with a completed database, will help provide that information for regulators, researchers, and planners in addition to its primary long term goal of providing lake information to the public, students, and teachers.

Methods, Procedures and Facilities:

Facilities:

The main database and operating system for PEARL are affiliated with the Water Research Institute and housed in the Spatial Engineering Department. To facilitate quick access, PEARL will run on a fast Pentium computer with 32 Mb of RAM, operating under a Windows NT Server. Netscape Communications Server software maintains our TCP/IP connection to the Internet. The data is stored in Microsoft Access. Software capabilities are changing so rapidly that software evolution is integral to the long-term management of PEARL. The wealth of data in PEARL and the demands of offering a searchable database have stressed the current PEARL server. Increasing the capacity and

speed of the PEARL server is an important part of this proposal. This increased capacity will allow the PEARL server to an optimal rate.

Accessibility:

Users access the database either over the WorldWide Web, or via URSUS, the University of Maine on-line library catalog system. Most Maine schools and libraries are connected to the Internet, providing easy access to a large segment of our target audience. However, Internet access is by no means universal. Access through URSUS makes it possible for anyone with the ability to connect to the University mainframe, or anyone with access to a public library, to connect to PEARL. In addition, this proposal will cover efforts to complete a downsized portable version of PEARL on a CD-ROM for laptop PC use in Project WET demonstrations and activities.

Users:

Students, science educators, naturalists, lake associations, planners, managers, researcher regulators, and many other interested parties use PEARL. Even tourists and prospective camp owners seek this information (DEP and WRI receive a number of requests about lakes from Realtors each year for instance). An immediate use will be in support of a Great Pond Classification System for Maine, a goal of the Governor's Great Pond Task Force (PI Kahl is a member of the task force). In addition, having Project WET participants access and use local PEARL information will be an integral part of Maine WET workshops.

Cooperators:

The cooperators will be the organizations represented by the Steering Committee, previously listed. The oversight of this Committee, largely by the University of Maine Water Research Institute, Department of Environmental Protection, and Volunteer Monitoring Program will accomplish the ongoing development of PEARL. Long term sustainability of PEARL will the responsibility of the WRI.

Related Projects:

Related projects on the World Wide Web. Work environments worldwide have been radically affected by the availability of inexpensive computers and Internet service providers. In rural Maine, distance education and telecommuting are especially important, making the World Wide Web emporium of advertisements, news, instruction, education, and research a significant emerging resource. Some Web sites are simply tools by which information is provided to the end user through pre-formatted, *static* pages of text and images. Other sites provide information in a *dynamic* environment that allows the user to query a database(s), the results of which are dynamically formatted and displayed. PEARL a dynamic WWW site, accepting query information from a user, selectively retrieving data from a database, and then presenting the information in the

format specified by the user. Dynamic, data driven databases are the most efficient Web sites and allow the most flexibility both for the end user and the Web site developer.

There are a number of examples of this dynamic type of Web site. Environmental Systems Research Institute (ESRI) is now marketing MapObjects software which are modular mapping functions which can be packaged to run mapping applications over the Internet. Several on line demos are available at *http://www.esri.com/base/products/internetmaps*. This software has been used as a base for developing GIS mapping functions within PEARL. The Department of Spatial Information Science and Engineering also has developed some JAVA applets which run over the Internet and can be repackaged to support functions in PEARL. Examples of some of these JAVA search, mapping and display tools developed for the Gulf of Maine project can be viewed at http*://basin.spatial.maine.edu:2000/demo.html*.

The California Environmental Management, Assessment, and Planning System (*http://ice.ucdavis.edu:80/ice_maps/)* is another example. This site allows a user to query the GIS system and databases at the University of California, Davis. The results of the query are maps and hyper-links to other information sources. Querying is a two step process. First, a user utilizes a clickable map of California to step down to maps of increasing scale with each click. Alternately, the first step can be achieved by choosing an area from predefined lists of counties, river basins, congressional districts, bioregions, and other criteria, or by typing in the name of a specified region. Step two involves retrieving data from categories that are available for the region specified in step 1. The categories are dynamically determined based on the available information for the region of interest. The result is a map or table displaying the information requested by the user or hyper-text links to other sources of information related to the users query. *The site displays many of the features that built into PEARL: The ability to choose a lake of interest by clicking on maps of ever increasing detail; the ability to dynamically query a database for lakes having a particular range of chemistry from within a region specified in the manner described above; the option of selecting a lake via clicking on a map, or by submitting a lake name via an interactive form; and the ability to specify what information a user would like to access through an interactive query.*

The Tiger Map Server (*http://tiger.census.gov/cgi-bin/mapbrowse*) maintained by the US Census Bureau was designed to demonstrate that public data and research could be delivered in a cost efficient manner on the Internet. It provides street level and regional maps for the United States. The maps can be used for general viewing, for research and analysis, in interactive map-based services, or downloaded as illustrations. Users submit either a name and state or latitude and longitude for the region of interest. Tiger uses this information to dynamically create a map of the specified region from GIS data stored within the database. One can then zoom in or out of the displayed map and also download the image as a Graphical Interchange Format (GIF) file. This site demonstrates the ease with which maps can be dynamically displayed over the Internet.

The Maine Office of GIS has a web page that offers a variety of searchable spatial databases (*http://www.apollo.ogis.state.me.us/mapping/mapframe.htm*). This dynamic

web site uses a map to identify search areas (by zooming) and certain geographic features have hyperlinked text or data summaries. This site contains information from several Maine agencies including some public water supply information.

The EPA Office of Policy, Planning and Evaluation maintains the web site at http://www.epa.gov/docs/oppe/spatial.html. This site provides links to spatial data, which is available from government agencies, specific projects, state agencies, local groups, and other current resources. The links include specific data sources, articles, software applications, and tools for understanding Geographical Information Systems (GIS) and spatial data relevant to the EPA. Some links are simple FTP (File Transfer Protocol) links that allow a user to download data, maps, and other information relevant to their interest. Other links are HTTP (Hyper Text Transfer Protocol) sites that provide further links to even more sources of information.

These examples demonstrate how data can be viewed, accessed, shared, and utilized over the Internet. When available over the Internet data can be accessed by resource planners, educators, policy makers, researchers, and the general public throughout the world. Although PEARL provides direct access to data, articles, and maps pertaining to Maine lakes, PEARL is a gateway to other natural resource databases.

An example of a Web site that provides links to a wide range of environmental information is found at *http://www.webdirectory.com/Water_Resources/.* The initial screen at this site allows a user to choose from a number of environmental topics such as *Hydrology, Lakes, States, Watersheds*, and many others. Each of these then provides further links to sites that are directly related to the primary category. For example, a link through the *Lakes* category allows access to the Great Lakes Information Management Resource (*www.cciw.ca/glimr/intro.html*) which is Canada's information repository for Great Lakes programs, publications and databases. This site provides information pertaining to many subjects within the Great Lakes region such as environmental monitoring, water quality, land use practices, fish and wildlife, and many others.

The National Environmental Information Service (http://www.neis.com) administers another site that provides links to resources that offer a wide variety of environmental topics. From here one can access resources related to environmental news, the US EPA, Regional EPA offices, state environmental agencies, environmental organizations, environmental law, and many other topics. These sites illustrate the wide breadth of information available over the Internet.

Maine lake information. PEARL utilizes existing information, continually updating the database as new information becomes available. The Great Pond Task Force has developed a list of variables pertinent to lake water quality, protection, regulation, and classification. In addition to this list, detailed water chemistry is available for nearly 700 lakes in databases at the University of Maine. The EPA Long Term Monitoring Project), collecting data on 18 lakes, has operated at the University of Maine since 1982 (Kahl et al., 1993). High Elevation Lake Monitoring (Kahl and Scott, 1988) sampled all 90 lakes in Maine above 2000 feet elevation in the 1980s. The Aquifer Lake Project also sampled

a special sub-population of lakes, those located in sand and gravel deposits, typically seepage lakes (Kahl et al., 1991). Other smaller projects have examined the lake chemistry in Acadia National Park (Kahl et al., 1985; Kahl and James, 1995), Moosehorn National Wildlife Refuge (Kahl, 1995), and a local mesotrophic lake (Houtman et al., 1995). Reports on lake data included evaluation of the effects of acid rain (Kahl et al., 1991), organic acids (Kahl et al., 1989), and eutrophication (Nieratko et al., 1992). Nieratko et al. (1992) working with PI Beard, correlated a wide variety of watershed characteristics in GIS with water.

These University data sources will be augmented by data previously mentioned from the Maine Volunteer Lake Monitoring Program. The VMP is one of the oldest volunteer programs in the U.S. Presently, 350 monitors collect information monthly from approximately 400 lakes. Some lakes have data records dating to the early 1970s. Maine DEP has lake data from other programs, including lake protection and restoration projects during the past 20 years. The Department of Inland Fish and Wildlife (IF&W) has fisheries data on almost 3,500 lakes, all still in paper files. PEARL will work with IF&W to incorporate these data.

This project will improve the linkage among numerous lake research and monitoring efforts in Maine (Table 2). In addition, Maine DEP is developing a new in-house database system based on the STORET beta version to be available soon. The DEP system will include river data which is presently being compiled and entered. We have had many requests for PEARL to include river data. While we intend that PEARL will eventually include rivers and groundwater data, a document library, and other resources, we will focus on lakes initially. We intend to design a state-of-the-art GIS-based database, upon which other information sources can be added.

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